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CLLEAN

CITIZENS FOR LOWRY LANDFILL ENVIRONMENTAL ACTION NOW

71 Algonquain Street • Aurora, CO 80018 • **(303) 912-2905 * berr@pcisys.net**

October 26, 2016

Katherine Jenkins
Public Affairs Specialist
US EPA, Region 8

Re: Citizens for Lowry landfill Environmental Action Now (CLLEAN) Comment on EPA 2017 5 Year Review

Dear Ms. Jenkins:

CLLEAN appreciates this opportunity to comment to EPA Region 8 on the 2017 5 Year Review.

Attached you will find:

- CLLEAN's response to EPA form questions, 1
- CLLEAN's White Paper - Changes in 1,4-dioxane Standards 2
- CLLEAN's White Ppaer – Data Interpretation for LLSF Site 3
- Letter dated November 14, 2013 to Timothy Shangraw, 4
- ~~CLLEAN Comments on March 31, 2012 RA/O&M comments for 2012 5 Year Review.~~
  Not included

CLLEAN believes that all of these documents must be reviewed by the contractor who is assisting EPA Region 8 with the 2017 5 Year Review if the 5 Year Review is to be completed with accurate data.

Please feel free to contact me if you have questions.

Sincerely,

Bonnie L. Rader

Bonnie Rader, President, CLLEAN

1

LOWRY LANDFILL Superfund Site Five-Year Review Interview Form

Site Name: LOWRY LANDFILL **EPA ID No.:** COD980499248
Interviewer Name: Katherine Jenkins **Affiliation:** EPA
Subject Name: BONNIE RADER **Affiliation:** CITIZENS FOR LOWRY LANDFILL ENVIRONMENTAL ACTION NOW
Time: **Date:**

1) Are you aware of the former environmental issues at the Site and the cleanup activities that have taken place to date?

Yes, we are aware. There have been no cleanup activities in the deep pits to date. The 138 million gallons of chemical waste remain buried under a 100' lift of clay and trash, making it more difficult to reach the pits to remediate.

2) What is your overall impression of the project, including cleanup, maintenance and reuse activities (as appropriate)?

Included is a copy of CLLEAN's comments during the 2012 5 Year Review. Not one of CLLEAN's concerns in the 2012 5 Year Review have been addressed. The project is not being cleaned up, the Record of Decision for the Lowry Site requires Containment. The Site cannot be reused. The chemicals are at least 2.5 miles off-site and probably more. Which proves that the Site is not In Compliance – containment has not been achieved. Operable Units 1 and 6 (shallow groundwater) have not performed as required. The LLSF Site is not meeting the ARARs. EPA is not enforcing the ROD at the LLSF Site.

3) What have been the effects of this Site on the surrounding community, if any?

Before the pits were covered, the chemicals traveled in the air for at least 8 miles. Many people had problems with nose bleeds, headaches, tingling hands and feet, heart issues and Bronchial Pneumonia with no fever. Once the pits were covered, those symptoms went away. At that time, residents knew when they were being impacted by chemicals from the pits at Lowry because of the odors and the oily film that covered their skin.

Now, the threat is more insidious, because the residents cannot smell or feel the chemicals from the pits. The chemical contamination that remains in the Lowry Landfill Superfund Site threatens to pollute the underground aquifers that serve the entire Front Range of Colorado, and our private domestic wells. Within a five-mile radius of the Site, there are four developments, all of which rely on groundwater for their domestic use. People are no longer worried about health impacts from the air, they are worried that the water they use will make them sick, and they won't know why until it is too late. Many are worried about how having chemicals in the groundwater under their homes will affect their property values. When the City of Denver and Waste Management say they have no intention of cleaning up the off-site plume, and EPA Region 8 concurred, this causes even more anxiety.

4) Have there been any problems with unusual or unexpected activities at the Site, such as emergency response, vandalism or trespassing?

Yes. The Contractor for the City of Denver and Waste Management has been manipulating the data from the LLSF Site to make it look like the Site is In Compliance. EPA, has not scientifically reviewed the data produced by the Contractor, or taken split samples to validate that the data from sampling by the Contractor is accurate, has been approving the Contractor's conclusions that the LLSF Site is In Compliance, when in reality, it is not In Compliance. In the meantime, the contamination from the LLSF Site has traveled north in the groundwater and onto private property.

5) **Has EPA kept involved parties and surrounding neighbors informed of activities at the Site?**

No. The last public meeting EPA held in the neighborhoods where the 1,4-dioxane plume has traveled was in 2006. It was a public meeting at which EPA announced the existence of an off-site plume and stated that the off-site plume posed no danger to the public because everyone uses City of Aurora Water. EPA refused to discuss that there are residents in the area who have private domestic wells, and do not use City of Aurora Water. At the meeting, EPA RPM Bonita Lavelle told the residents that EPA would keep them up-dated on a regular basis. The next update from EPA was 7 years later, 2013, when the EPA released a new Fact Sheet. The new Fact Sheet had a number of statements that CLLEAN did not want included because they were misleading to a public who was not directly involved in the Site. EPA released the Fact Sheet to the public with the misleading information.

The City of Denver, Waste Management and their PR Firm, Intermountain Public Affairs, began a concerted effort to prevent CLLEAN from participating in the process. The EPA Public Involvement Coordinator did not object on behalf of CLLEAN, even though CLLEAN is a TAG recipient and it is EPA's mandate, under SARA, to include impacted stakeholders in the entire process.

a) **Do you feel well-informed regarding the Site's activities and remedial progress?**

Yes, by our own persistence, we are well informed.

As no-one is remediating at the Site, there is no remedial progress.

If anything, the Site is in worse condition because the EPA has not acted as a Lead Agency and EPA has blindly accepted the City of Denver and Waste Management's manipulated data, which says the Site is In Compliance. CLLEAN data proves that the Site is not In Compliance and EPA Washington, D.C. Headquarters Scientists agree with CLLEAN.

b) **How can EPA best provide site-related information in the future?**

By providing regular updates to CLLEAN who will use their current outreach email and flyer distribution list to reach the community.

(3) (2)

Changes in 1,4-Dioxane Standards and the Lowry Landfill Superfund Site

A Brief Review Provided By CLLEAN
June 18, 2013

This brief discussion of the changes in the 1,4-dioxane standards and the Lowry Landfill Superfund site has been developed to provide basic information to stakeholders regarding this important change. As detailed in the requests below, CLLEAN is also proposing that discussions between the stakeholders, regulatory agencies and responsible parties should begin immediately to discuss changes needed to meet this requirement including its effect on the use of historical data and the Site Conceptual Model.

In 2012, the Colorado Water Quality Control Commission revised the Basic Standards for Groundwater (Regulation#41, 5 CCR 1002-41) and the organic chemical standards in the Basic Standards and Methodologies for Surface Water (Regulation #31, 5 CCR 1002-31). The changes included reducing the groundwater standard for 1,4-dioxane to 0.35 µg/L on January 31, 2013 from 3.2 µg/L. Prior to the 3.2 µg/L standard, the interim standard was 6.1 µg/L, promulgated in 2005. In addition, the same changes are applied to surface water segments classified for water supply. The changes in 1,4-dioxane standards are based on the August 2010 1,4-dioxane human health criteria update in IRIS.

The new 1,4-dioxane standards are well below the 5 µg/L Practical Quantitation Limits (PQL) for the Lowry Landfill Superfund site, in use by 2006 and developed due to the 2005 interim standard of 6.1 µg/L. When these were again provided to CLLEAN as part of the May 30, 2012 "Addendum No. 4 to the Groundwater Monitoring Plan," CLLEAN responded with a request for lower detection limits and subsequent PQLs plus additional technical review of methods. CLLEAN has determined that the 5 µg/L PQL for Lowry Landfill is not based on current analytical methods and typical results under similar site conditions.

Regulation 41 allows the PQL to be used as the groundwater standard if the PQL exceeds the groundwater standard. Therefore, the PQL of 5 µg/L has been used as the groundwater performance standard for Lowry Landfill Superfund Site since the standard dropped from 6.1 to 3.2 and subsequently to 0.35 µg/L. A revised 1,4-dioxane PQL study for groundwater is anticipated in 2013. For surface water and Regulation 31, the responsible parties have previously argued Regulation 31 standards do not apply due to the distance between Murphy Creek and the South Platte River. Based on the recently lowered 1,4-dioxane standard and uncertainty regarding the extent of surface water containing 1,4-dioxane in excess of 0.35 µg/L, this assertion is in question. In other words, surface water in Murphy Creek, potentially orders of magnitude higher than the standard, is an issue for the South Platte River.

The relatively high detection limits tolerated for this site have limited data interpretation, trend analysis and other management and assessment tools as summarized in CLLEAN's comments on Addendum No. 4. CLLEAN's comments were similar to those found in an August 1, 2012 letter from Sandra Spence, Chief Water Quality Unit, U.S. EPA Region 8, Regarding "Rebuttal Comments on Proposed Revisions to the Organic Chemical Standards in Regulation 31 and 41" (Ref: 8EPR-ED).

> *"Comments were submitted noting the lack of methods for measuring 1,4-dioxane at the level of the proposed standard. Even if this assertion were true, it would not alter the requirement to adopt a protective criterion based on sound science. The written testimony from the EnviroGroup Limited claimed there was no analytical method that would measure 1,4-dioxane at a concentration below 3.2 µg/L. In fact, EPA has developed a method (Method 522) that has a method-reporting limit near 0.05 µg/L. An important practical consideration is that NPDES enforcement actions are based on exceedance of water quality-quality effluent limits (WQBELs) in permits. As such, analytical detection levels are more properly considered in an enforcement context, and not when determining/adopting protective ambient water quality criteria."*

CLLEAN agrees with Region 8 that 1,4-dioxane can be measured at concentrations as low as 0.05 µg/L. Groundwater north of the site would not be expected to be a challenge to these analytical methods unless there are unreported site related constituents in these offsite wells. Some site groundwater and influent into the treatment system may provide for more challenging conditions, for example it may require dilution due to interference from other substances in the water, but the discussion remains that if site standards (the unusually high PQL) apply to conditions contaminated by the site but considered "offsite" for unknown reasons.

In addition to the need for a realistic PQL for 1,4-dioxane, the health risk based assessment associated with the new standard requires review of previous risk assessment calculations at the Lowry Landfill regarding 1,4-dioxane. In the letter from Sandra Spence quoted above, EPA Region 8 also states that:

> *"The proposed new and revised standards were calculated correctly using the methods in WQCC Policy 96-2, and are consistent with the risk assessments in EPA's Integrated Risk Information System (IRIS). As such, we believe the proposed standards are based on sound scientific rationale and protective of use classifications, as required by the EPA regulation at 40 CFR Section 131.11(a)(1)"*

This statement is an important vote of confidence by EPA for the August 2010 update in IRIS for 1,4-dioxane. Subsequently, the risk assessment calculations associated with Murphy Creek prior to 2010 should be reviewed and potentially revised with the new information. It should be noted that recalculations of risk is needed but should be based on new data that accounts for lower detection limits now available. Additional sampling of surface water is likely needed.

With site data presented and projects scoped using the higher, older standard, this change should have a significant effect on site management, more specifically risk management decisions. Historical data reported as "non-detect" could, in many cases, potentially be above the current standard. A number of other tasks, listed below, are now needed to address issues created by the new standard.

CLLEAN is requesting the following from EPA and the responsible parties:

1. Revise the Groundwater Monitoring Plan to change the PQL from 5 μg/L to a level well below the 0.35 μg/L standard, based on the forthcoming 2013 1,4-dioxane PQL study results. Currently, data found to be non-detect could actually be more than an order of magnitude above the standard. This will require the Responsible Parties to present a work plan and the subsequent results of the PQL study to stakeholders and regulatory agencies for technical review.
2. Assessment of the 1,4-dioxane plume beyond the northern boundary of the site originally was scoped based on the 6.1 μg/L standard. A new work plan will be required to expand the assessment to determine the extent of the plume based on the new, lower standard.
3. A new factsheet or other public document showing the extent of the plume based on the new standard is needed. Previous maps are based on the 6.1 standard. Previously, regulatory agencies and the responsible parties had agreed to use the standard as the extent of the plume.
4. Reconsideration of the threat from 1,4-dioxane in Murphy Creek, a surface water featured determined to contain 1,4-dioxane from the site and located in residential area immediately downgradient from the Lowry Landfill Site. Previous assessment used assumptions from now outdated IRIS information and detection levels orders of magnitude higher than the current standard.

(2) (3)

Data Interpretation for the Lowry Landfill Superfund Site A Review of currently used Statistical Methods

Prepared by CLLEAN July 24, 2013, 2013

Table of Contents

Introduction

Site management at the Lowry Landfill Superfund Site includes the collection of a large amount of expensive analytical data. The data is used to determine both compliance with standards applicable to the site (compliance monitoring) and the performance of site containment and treatment facilities (effectiveness of containment features). Data is collected into a site database and a number of statistical methods are used to interpret the data. Over the past several years, CLLEAN has provided comments on a number of problems and issues with the statistical methods used to interpret data from the Lowry Landfill Superfund Site. Problems have included incomplete reporting; missing assumptions, poorly labeled output and missing output, as well as issues with applications of methods where results could not be replicated from the data provided by the responsible parties. Some of these issues have been addressed; others persist in the current Remedial Action and Operation & Maintenance Status Reports (O&M reports). Details of CLLEAN concerns and comments can be found in previous comments by CLLEAN for the current and historical O&M reports.

Due to these re-occurring issues, it has become apparent that there is a need to revise the current Groundwater Monitoring Plan (GWMP). CLLEAN has identified a number of issues with the GWMP including those highlighted in the comments for the Second O&M Report for 2012. Specifically, one of the more important issues regards the statistical methods selected. There appears to be some problems with the original method described in Appendix C of the GWMP labeled "Methods for Statistical Evaluation of Groundwater Monitoring Data Revision 1, December 28, 2005." In addition, in 2009 EPA produced a revised guidance, the 1992 version of the "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities" cited in the current GWMP, Appendix C has been replaced by a 2009 update. The update of this important EPA guidance is applicable to the methods selected for the Lowry Landfill Superfund Site.

Similar to the GWMP, Appendix C, presentation of statistical methods, this discussion is divided into two sections below; *Effectiveness of Containment Features* and *Compliance Monitoring*.

Effectiveness of Containment Features:

Sen's Test for Trend

The current EPA statistical guide (EPA 2009) does not include Sen's Test as a trend test, which is the primary trend test in the current Lowry GWMP. Mann-Kendall Trend Test and the Theil-Sen Trend Line are recommended for non-parametric detection and estimate of trend respectively in the current EPA statistical Guide (2009). Sen's test is considered more inexact in the presence of missing values, non-detects and trace data. Sen's test is not recommended if the number of non-detect measurements approaches half the total number of values (greater than (n-1)/2). An increasing number of non-detects may severely impair the ability of the method to predict confidence intervals (Gilbert 1987).

The issue of non-detects is discussed in Appendix C of the GWMP (Section 2.2.1 Sen's Test for Trend). However, the issues with applying Sen's Test was not resolved nor were other alternatives evaluated.

The selection of trend testing in the GWMP also omits any seasonal trend testing. Seasonal Mann-Kendall can often provide insight into site conditions as multiple years of data becomes available. With seasonal changes in groundwater level observed at the site, application of seasonal trend testing is needed, otherwise, seasonal changes can mask trend by increasing variability.

Changing to Mann-Kendall Trend Test and the Theil-Sen Trend Line along with seasonal trend tests, can improve the interpretation of trend data. Although Sen's test is still found in the ASTM Standards (2012 and 2010), Mann Kendall is presented as an option in the ASTM and recommended in the current EPA guidance (2009). In summary, this change is consistent with changes in the EPA guidance (2009) and the current ASTM Standards (2012 and 2010).

Shewart-CUSUM Control Charts

CLLEAN was informed during a technical meeting (June 26, 2012) that control charts are no longer being used. Documentation regarding this decision or what methods replaced Shewart-CUSUM Control Charts was not provided. CLLEAN was not directed to the proper work plans or amendments to monitoring plans that may have provided this needed information.

CLLEAN agrees that Shewart-CUSUM Control Charts are likely not appropriate for the site. As indicated in EPA 2009 (page 17-22), Shewart-CUSUM Control Charts are sensitive to assumptions of normality. Appendix C of the GWMP entitled Section 2.2 Statistical Evaluation of Chemical Trends cites Gibbons 1999 which also explores this subject:

"*The method* (Shewart-CUSUM) *assumes that there are no background measurements (e.g., measurements from prior sampling events) and that these observations....are independently and normally distributed or can be suitably transformed to approximately a normal distribution.*"

ASTM 2012 also includes Shewart-CUSUM as an option, but includes the same warning regarding data distribution.

On page 34 of the current Lowry O&M plan for the second half of 2012, it refers to CUSUM with "CUSUM" lines appearing without additional description in Appendix C-4.3 that are also labeled "Analysis prepared using Sen's Test for trend and Lowry Statistical Software". However, this may be part of a previous issue identified by CLLEAN: "the RPs appear to be unable to modify the output from their historic statistical software to meet current site needs."

Shapiro-Wilk Test

It is notable that a test for normality, Shapiro-Wilk test, is specified for compliance monitoring, but not for containment monitoring. Where non-detect values are expected or may occur, it is always important to test for normality if analysis of a reasonable amount of data depends on parametric methods. This may not be as important as the expectation of a non-parametric test joined to one assuming parametric data. This requires the assumption that data is applicable to a non-parametric method when less than 8 data points are available and parametric (normally distributed) when more than 8 points are available.

In summary, EPA 2009 replaced EPA 1992, an important guidance used to develop statistical methods in the current Groundwater Monitoring Plan. The 2009 guidance includes direction on selecting trend analysis methods that is applicable to the site and is different from the choices made in the current GWMP (Appendix C). Consequently, decisions are currently being made based on data analysis inconsistent with current EPA guidance. There are needed changes in the process, including better use of the Shapiro-Wilk or other tests, are needed to determine if Shewart-CUSUM or another tests are appropriate. This will require the review and recalculation of statistics applied to historical data.

Compliance Monitoring

Compliance monitoring includes Sen's test and suffers the same limits discussed above. In addition, trend testing should also include seasonal trend tests for the same reason as indicated above.

The first method that requires additional review is the application of Aitchison's Method. The recommendations regarding this method have changed since prior EPA guidance. According to EPA 2009:

One non-detect treatment recommended in past EPA guidance — Aitchison's method (1955), as applied to groundwater[3] — assumed that non-detects were actually free of the contaminant being measured, so that all non-detects could be regarded as zero concentrations. In some cases, if an analyte has been detected infrequently or not at all in background measurements, and/or all non-detects are qualified as "U" (i.e., undetected) values, this assumption may be practical, even if it cannot be directly verified. Another example might be seasonal changes in groundwater elevation at wells located on the edges of a contaminant plume. Parameters detectable at certain times of the year may be non-detect during other seasons, even within the same well. Such non-detects may result from a different data generating mechanism, due to seasonal changes in groundwater chemistry, and so may not follow the same distribution as detects.

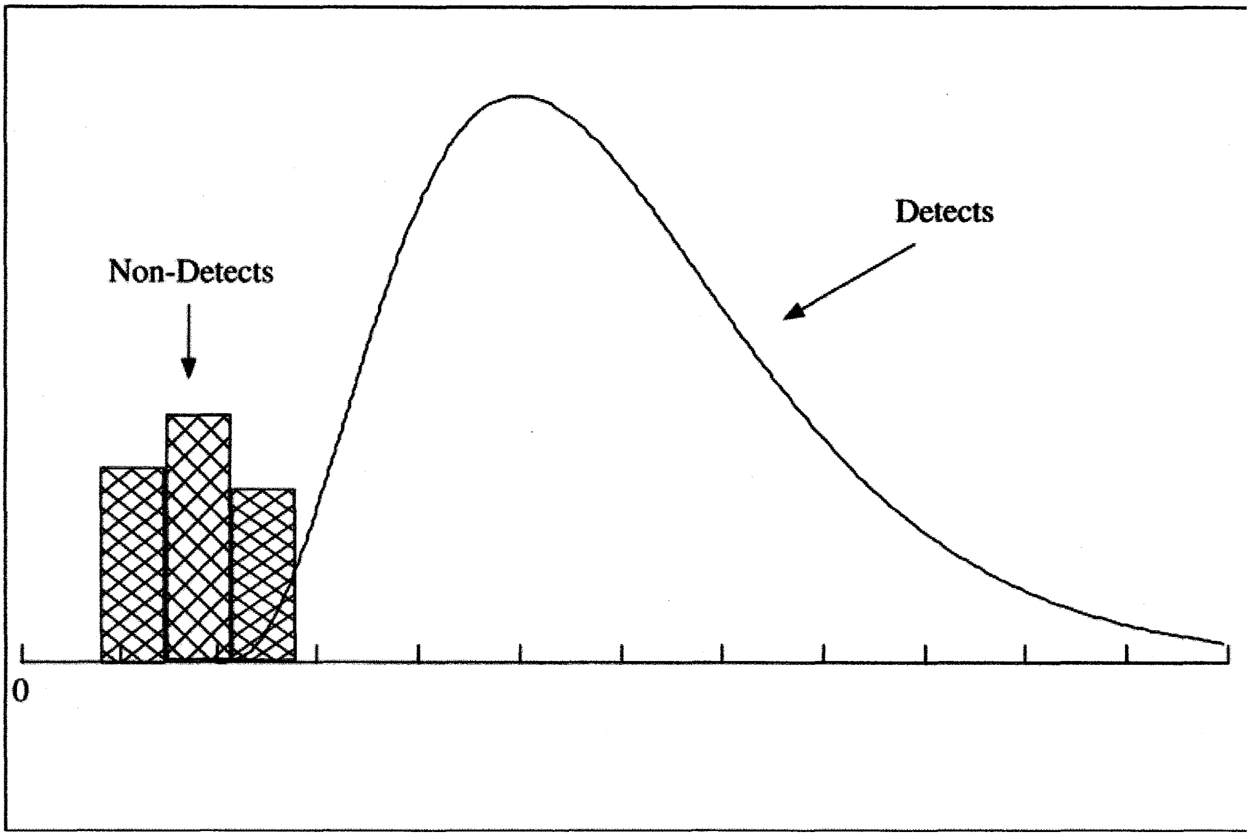

Figure 1. Figure 15-2 from EPA 2009, Modified Delta Model for mixture distribution of detects/non detects.

*More generally, Aitchison's original model posited a 'spike' of zero-valued measurements, combined with a lognormal distribution governing the detected values. A modification to Aitchison's model known as the modified delta method[4] (USEPA, 1993) has been found to be more practical and realistic in many circumstances (**Figure 1**). Instead of assuming that all non-detects represent zero concentrations, the modified delta method assumes that non-detects constitute a separate, discrete distribution. When combined with the detected values, a mixture distribution is formed consisting of a continuous detected portion (usually the normal or lognormal distribution) and a discrete non-detect portion. Rather than assuming that all non-detects are zeros, the modified* *delta model assigns all non-detects at half the reporting limit [RL]. (Note: this might be a method detection limit [MDL], a quantitation limit [QL], or a contract RL). This method can accommodate multiple reporting limits since each non-detect is assigned half of its possibly sample-specific RL. It can also accommodate low-valued detects intermingled with the non-detects, since the non-detects and detects are modeled by distinct distributions.*

[3] Aitchison's model was not originally applied to concentration data. More typical applications were in the fields of economics and demographics.
[4] The original Aitchison model was termed the delta-lognormal, so called because it presumed that the data consisted of a mixture of two distinct populations: 1) a lognormal distribution representing the observed continuous measurements, and 2) a 'spike' of values, known as a delta function, located at zero.

This is further complicated by what is found in Gibbons and Coleman (2001) (cited in the GWMP) and the current ASTM (2012) Standard, which states that "if $m \geq 8$, a good choice is to use Aitchison's (1955) method" where m refers to the number of values use to compute the mean in this particular reference. The method in the GWMP directs Aitchison's to be used if the number of values is *less than* 8. The result of the questionable application is the calculation of substitute values for non-detects that can reduce the effectiveness of subsequent analysis. This results in a poor data set for these calculations and increased uncertainty. The only way to quantify the effect is to repeat the calculation with a more appropriate method and compare results.

The next method that requires review is the Dixon's test for outliers. This is an effective method for $n \leq 25$, but for the larger data sets that are now evaluated from the site, Rosner's test is recommended when $n \geq 20$. In the event Dixon's is used with the larger sets, the analysis becomes more vulnerable to masking (EPA 2009).

It should also be noted that Dixon's test also assumes reasonably normally distributed data. The specified test for normality, Shapiro Wilk, does not link its results to the Dixon's test step.

The control measures are also presented without reference. Although confidence intervals are demonstrated for applications such as this in EPA (2009), ATSM Standards (2012 and 2010), and Gibbons (1999); no information regarding assumptions to develop the test parameters is found in the GWMP. With modified data coming to the calculations via inappropriately applied method for handing non-detects and issues with preliminary evaluation for outliers and normality tests, the uncertainty coming into the tests at this point of the procedure creates unnecessary uncertainty in the outcome.

References Cited

ASTM. 2012. Standard Guide for Developing Statistical Approaches for Groundwater Detection Monitoring Programs. D6312-98 (Reapproved 2012)

ASTM. 2010. Standard Guide for Applying Statistical Methods for Assessment and Corrective Action Environmental Monitoring Programs. D7048-04 (Reapproved 2010)

EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. March. EPA 530/R-09-007.

Gibbons, R.D. 1999. Use of Combined Shewhart-CUSUM Control Charts for Ground Water Monitoring Applications. Ground Water. Vol. 37. No. 5. September-October.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. ISBN 0471288780.

4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
Denver, CO 80202-1129
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www.epa.gov/region8

November 14, 2013

Ref: EPR-SR

Mr. Timothy C. Shangraw, P.E.
Engineering Management Support, Incorporated
7220 West Jefferson Avenue, Suite 406
Lakewood, Colorado 80235

Re: Evaluation of Groundwater Monitoring Plan Procedures and Statistical Analysis Methods used to Determine Compliance with Groundwater Performance Standards, Lowry Landfill Superfund Site

Dear Mr. Shangraw,

The U.S. Environmental Protection Agency (EPA) recently completed the review of the 2012 *Remedial Action and Operations & Maintenance Status Reports – January through June and July through December 2012 – Lowry Landfill Superfund Site, prepared by Engineering Management Support, Inc.*, dated September 30, 2012 and March 31, 2013, respectively. The review identified an issue with groundwater compliance and effectiveness data that could potentially affect groundwater compliance decisions and data reporting accuracy. As a result of this finding, an evaluation was conducted of your groundwater monitoring plan procedures and statistical analysis methods used to determine compliance with groundwater performance standards.

Enclosed are the findings from the evaluation along with alternative technical approaches submitted for your review and consideration. A response to this evaluation is required at your earliest convenience but, in any event, no later than thirty days from the date of this correspondence. Should you have any questions regarding this matter, please don't hesitate to contact me at (303) 312-6224 or sims.leslie@epa.gov.

Sincerely,

Leslie Sims
Project Manager
EPA Superfund Remedial Program

Enclosure

cc: Steve Wharton, EPA
Deana Crumbling, EPA
Andrew Schmidt, EPA
Amelia Piggott, EPA
Dan Powell, EPA
Lee Pivonka, CDPHE
Bonnie Rader, CLLEAN

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31

An example of this issue appears in the excerpt from Table 1 below for 1,4-dioxane (red underline).

Table 1

Confidence Intervals for Comparing the Mean to a Regulatory Standard

Constituent	Units	Well	N	% Detected	Mean	90% LCL	95% UCL	Standard	Limit Type	Trend	Notes
1,1,1-trichloroethane	ug/L	B-326-WD	22	0.864	0.160	0.000	0.046	200.000	normal	dec	
1,1,2,2-tetrachloroethane	ug/L	B-326-WD	22	0.000	0.200	0.200	0.200	1.000	nonpar		
1,1,2-trichloroethane	ug/L	B-326-WD	22	0.000	0.270	0.270	0.270	5.000	nonpar		
1,1-dichloroethane	ug/L	B-326-WD	22	0.864	0.220	0.000	0.154	990.000	normal	dec	
1,1-dichloroethene	ug/L	B-326-WD	22	0.773	0.230	0.000	0.137	7.000	normal	dec	
1,2-dichloroethane	ug/L	B-326-WD	22	0.000	0.130	0.130	0.130	5.000	nonpar		
1,2-dichloropropane	ug/L	B-326-WD	22	0.182	0.155	0.099	0.210	5.000	nonpar		
1,4-dioxane	ug/L	B-326-WD	43	1.000	0.000	0.000	0.000	5.000	normal	dec	
Acetone	ug/L	B-326-WD	22	0.136	2.100	2.300	1.900	1600.000	nonpar		

2. There are other instances where a decreasing trend is present for a particular analyte, but the entries in Table 1 deviate from the pattern in #1. Instead of entering the "mean" as 0.000, a non-zero value is given that would appear to be an actual concentration. (There are no footnotes with any data tables that would indicate otherwise). Examination of the Access database, however, shows the values portrayed as "means" are actually the laboratory's method detection limits (MDLs) for those analytes. Once again, the "mean" value in Table 1 does not present the true mean concentration for the "N" data points referenced. Examples of this are shown in the same Table 1 excerpt above, for the analytes 1,1-dichloroethane and 1,1-dichloroethene (blue underline). The 90% LCLs are given as zero, and the 95% UCLs are given as values for which EPA cannot ascertain the derivation. This pattern of "mean" misrepresentation appears when the "% Detected" is less than 100%, but greater than zero. This will also be discussed in more detail below.
3. In cases where a particular analyte has never been detected in a well ("% Detected is 0.000"), the laboratory's MDL is entered as the mean and for both the LCL and UCL. This is illustrated in the Table excerpt above by 1,1,2,2-tetrachloroethane and 1,1,2-trichloroethane (green underline).

   A more appropriate way to report this data would be to report the mean as less than the MDL (<MDL), and report the confidence limits as not applicable (N/A). In other words, the Table 1 entries could appear as immediately below (in the shaded columns):

Constituent	Units	Well	N	% Detected	Mean	90% LCL	95% UCL	Standard
1,1,2,2-tetrachloroethane	µg/L	B-313	22	0.000	<0.200	N/A	N/A	1.000
1,1,2-trichloroethane	µg/L	B-313	22	0.000	<0.320	N/A	N/A	5.000

   If the database that populates Table 1 has been constructed in such a way that entries such a "<" and "N/A" are not permitted and this cannot be rectified, a footnote reference should be entered into the existing "Notes" column of Table 1 (not shown in the reproduction above) to explain. See the check-marked column.)

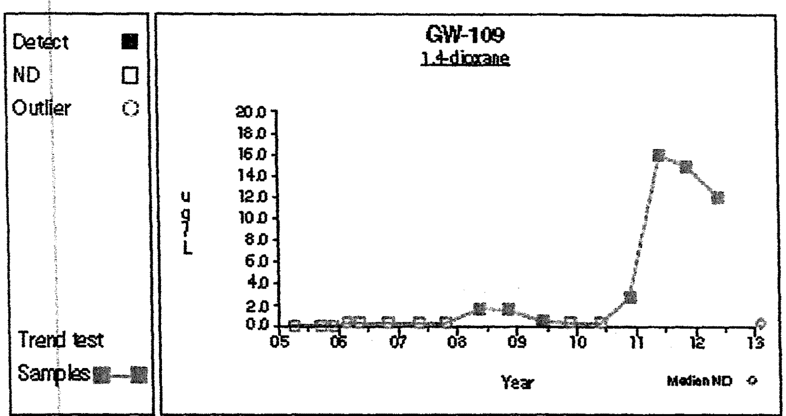
Constituent	Units	Well	N	% Detected	Mean	90% LCL	95% UCL	Standard	Limit Type	Trend	Notes
1,1,1-trichloroethane	ug/L	B-313	22	0.136	0.180	0.199	0.160	200.000	nonpar		✔
1,1,2,2-tetrachloroethane	ug/L	B-313	22	0.000	0.200	0.200	0.200	1.000	nonpar		
1,1,2-trichloroethane	ug/L	B-313	22	0.000	0.320	0.320	0.320	5.000	nonpar		

4. It may also be noted that since the column heading is "% Detected," the values should appear as xx.x, since the heading specifies a "percent." However, the Table 1 entries are given in decimal form, 0.xxx. Perhaps the "%" could be dropped.

Att XIV

5. Another issue is that statistics reported in the Status Report uses substitution of zero for NDs for at least some instances when determining trend and calculating well statistics. As noted in the Unified Guidance, for "estimation of parameters such as the mean and variance...simple substitution methods tend to perform poorly, especially when the non-detect percentages are high... The McNichols & Davis study in particular found that none of the simpler methods for handling non-detects did well when the underlying data came from a skewed distribution and the non-detect percentage was over 50%." (page 15-2). For calculating statistics and performing statistical tests, the guidance "generally favors the use of the more sophisticated Kaplan-Meier or Robust ROS methods which can address the problem of multiple detection limits" (page 15-3). The guidance observes that trend determination may be a problem under certain circumstances no matter what technique is used to handle NDs. However, common sense should prevail.

For example, simple observation shows that the 1,4-dioxane summary data for Well GW-109 (below) display an increasing trend (see graph below reproduced from Status Report).



Graph 548

Prepared by: Parsons

However, Table 4.6 of the Status Report answers "None" for "Is there a trend?" This is an example of where substituting 0 for NDs caused the mean and confidence limits to be erroneous and the Sen test to incorrectly indicate "no significant trend." Since this conclusion contradicts direct observation, the conclusion of "no trend" should have been double-checked. Using the Kendall-Mann Trend Test (available in ProUCL5), there is high significance for an increasing trend at 95% confidence, even when zeros are substituted for the NDs. Running the ProUCL Theil-Sen Trend Test with ½-DLs for NDs, or DLs for NDs give a significantly increasing trend at 95% confidence. Also, the Theil-Sen test *is* significant for an increasing trend when "ND = 0" if the confidence used is 90% (instead of 95%). The correct statistics are shown below.

This table examines the 1,4-Dioxane summary for well GW-109

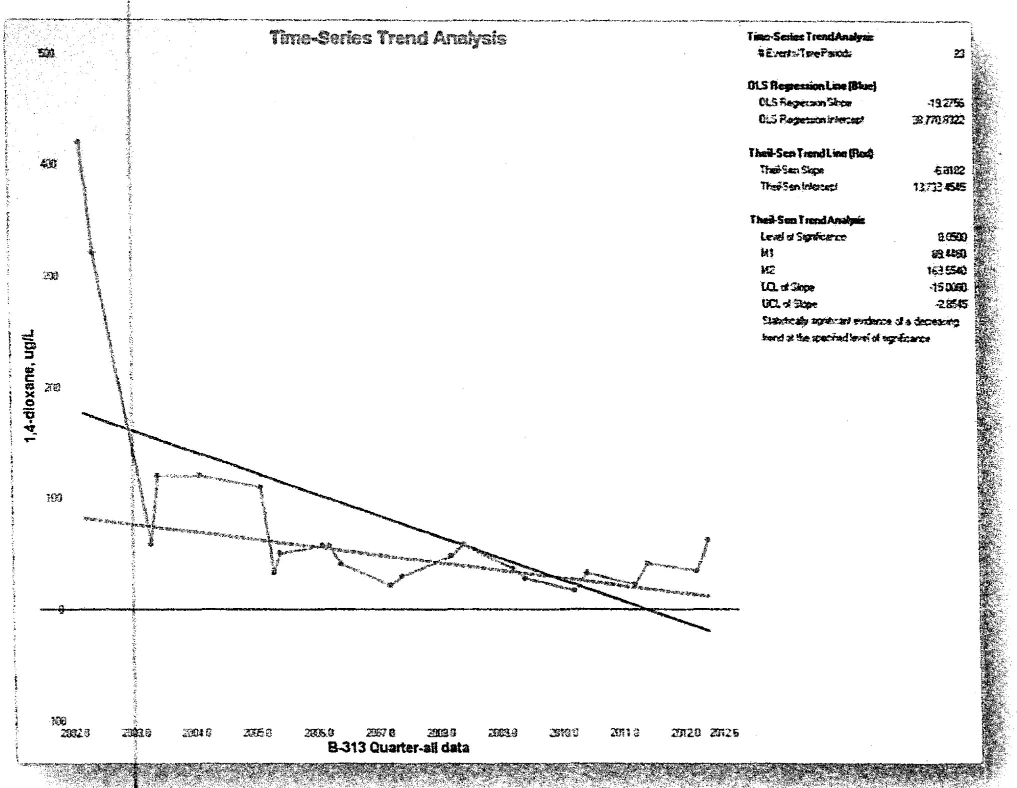
Data Set & ND-Handling Technique	Data Set "n"	Number of NDs	Mean	90%LCL	95%UCL
GW-109 1,4-Dioxane (unable to reproduce the statistical values presented in Table 4.6)					
Given in Status Report's Table 4.6 (Mar05-Nov12)	18	10	3.4	0	12
Properly reported for full data set	18	10	3.26	1.5	5.55
Since detections began (May08-Nov12)	10	2	5.[illegible]	3.00	9.45
GW-109 1,4-Dioxane: Table 4.6 incorrectly says there is no trend. The Mar05-Nov12 data set shows an increasing trend.					
Table 4.6 correctly states there is insufficient data to make a compliance decision.					

The Unified Guidance provides recommendations for ND-handling techniques that avoid simple substitution of 0, ½DL or DL values for NDs (see page 15-2). Using the Kaplan-Meier (KM)

41

The table also shows that the "Minimum Detected Value" was 18 ppb, and the highest value was 420. Under those conditions it is mathematically impossible for the mean of these 23 values to be 0. Also, all of the 23 data points were well above the 5 ppb performance standard. Yet the "Compliance Decision" is that data are "insufficient" to draw a conclusion about whether the well is in compliance with the performance standard of 5 ppb. To examine that conclusion more closely, the raw 1,4-dioxane monitoring data were obtained from the database and evaluated. Figure 1 below is a plot of the concentration data vs. monitoring date for well B-313.

Figure 1. Plot of B-313 1,4-Dioxane Monitoring Data



The **downward slanting solid blue line** is the "best fit" linear regression line for the 23 data points. The x-axis, where concentration = 0, is the horizontal solid black line. (note - its appearance as an upward slanted line is an optical illusion caused by the downward sloping blue and red lines.) The Theil-Sen Trend Line is the **dashed red line.**

It is apparent from Figure 1 that the slope of the **blue linear regression line** is heavily influenced by the very high concentrations in 2002. Ordinary least squares (OLS) linear regression is a "parametric" statistical procedure, which means it is sensitive to the magnitude of high or low data points (how high or how low they are). The higher the first few monitoring results, the steeper the line's slope whether or not later concentrations continue to drop, as long as the concentrations remain significantly lower than the initial data points. The steeper the slope, the more likely the regression line will cross the x-axis, allowing the GWMP to claim a "mean = 0."

4

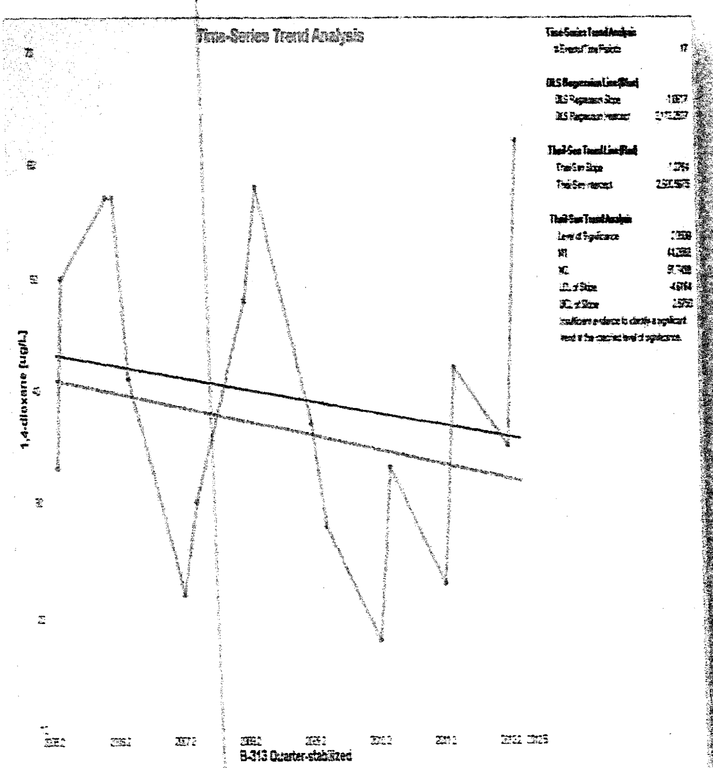
Alternatives to the GWMP Regression Procedure

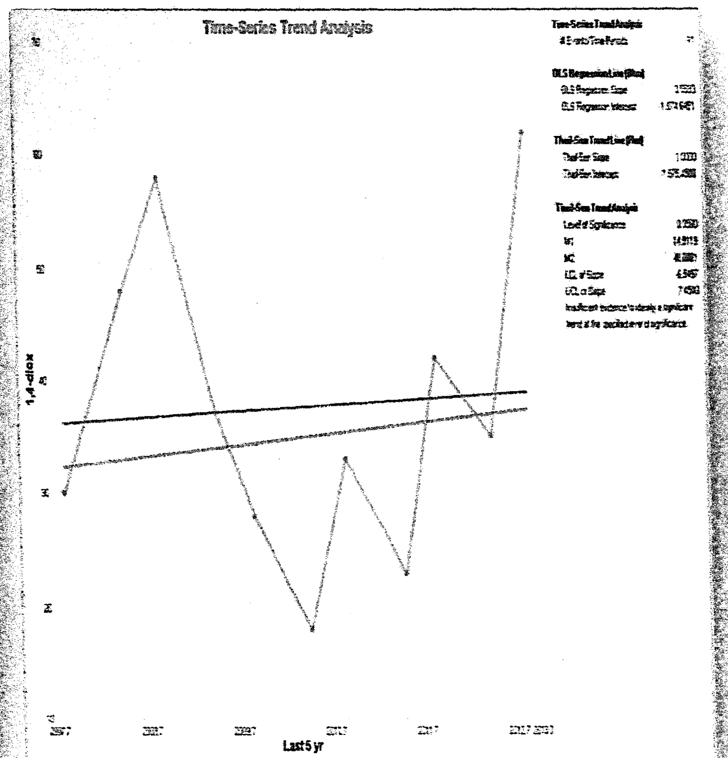
The below table provides alternatives, and contrasts them with the summary data reported in Table 6.4 and with calculating summary statistics from all data points, including the few very high ones when the well was installed.

Data Source for Well B-313 1,4-dioxane	Trend?	Data Set Mean	90% t-LCL	95% t-UCL	Chebyshev 90% LCL	Chebyshev 95% UCL
From Table 6.4	Dec	0	0	34	—	—
All 23 data points (data non-normal distribution)	Dec	79.2	N/A	N/A	18.3	168
After concentrations stabilized (Sep05 to Nov12, n=17) (data normal distribution)	No	39.7	35.2	45.5	N/A	N/A
Last 5 years of data (Nov07 to Nov12, n=11) (data normal distribution)	No	37.6	31.9	45.2	N/A	N/A

The Chebyshev confidence limits are used for the n = 23 data set because this data set has a non-normal statistical distribution. Hence, it is inappropriate to use the common Student's t confidence limits. Data sets that include data points only after the concentrations stabilize show normal distributions and t-LCLs and t-UCLs are appropriate.

It can be seen that the summary statistics for the stabilized data set (n = 17) and for the data set containing the last 5 years of monitoring data (n = 11) are nearly identical. Either option presents an honest picture of the "mean." It is clear that there is sufficient data to determine that the well is out of compliance. For completeness, both data sets are plotted below. Note that the scale of the y-axis is different from Figure 1.





Detailed Discussion of Issue #2

Issue #2 involves instances where a decreasing trend is present for a particular analyte and the linear regression line crosses the x-axis. However, instead of entering the "mean" as 0.000 as was done for B-313 1,4-dioxane, non-zero values appear in tables of summary statistics. Recall that this was an issue for certain analytes for Well B-326-WD (black rectangle below).

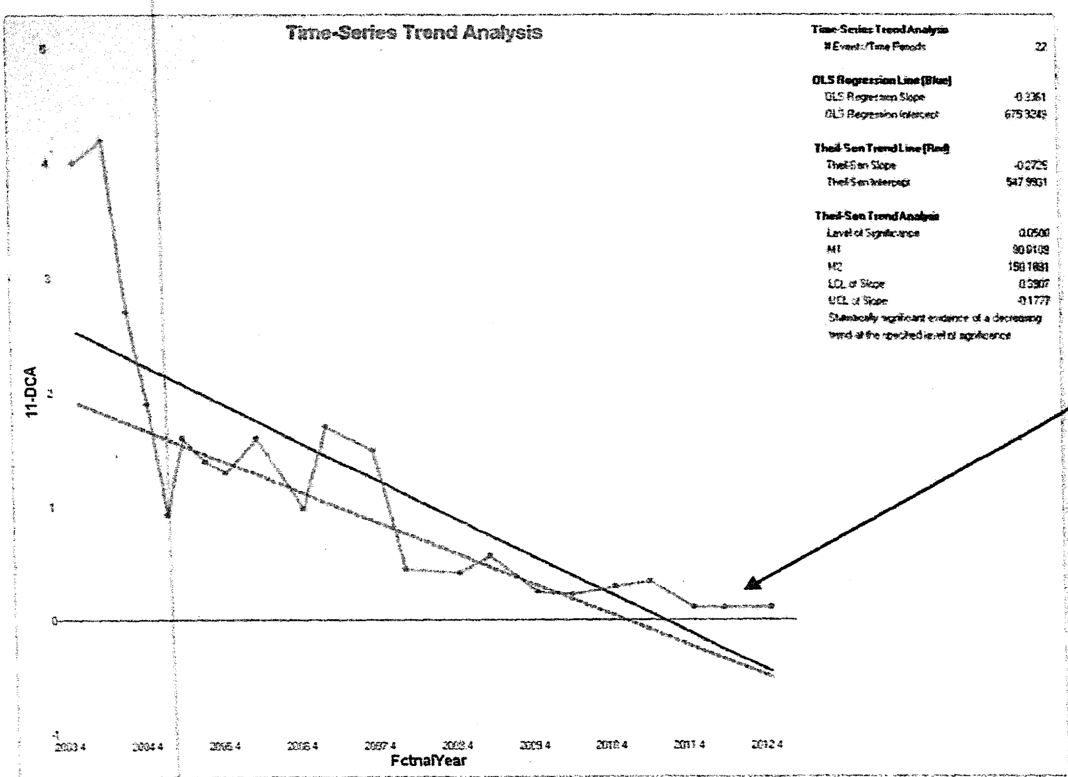
Without examination of the raw data in the database, these would appear to be actual concentrations below performance standards. Examination of the database shows that these non-zero values are the laboratory's MDLs for the respective analytes. The strategy of entering MDLs for decreasing concentrations appears to depend on the presence of non-detects (NDs) in the data set.

Table 1

Confidence Intervals for Comparing the Mean to a Regulatory Standard

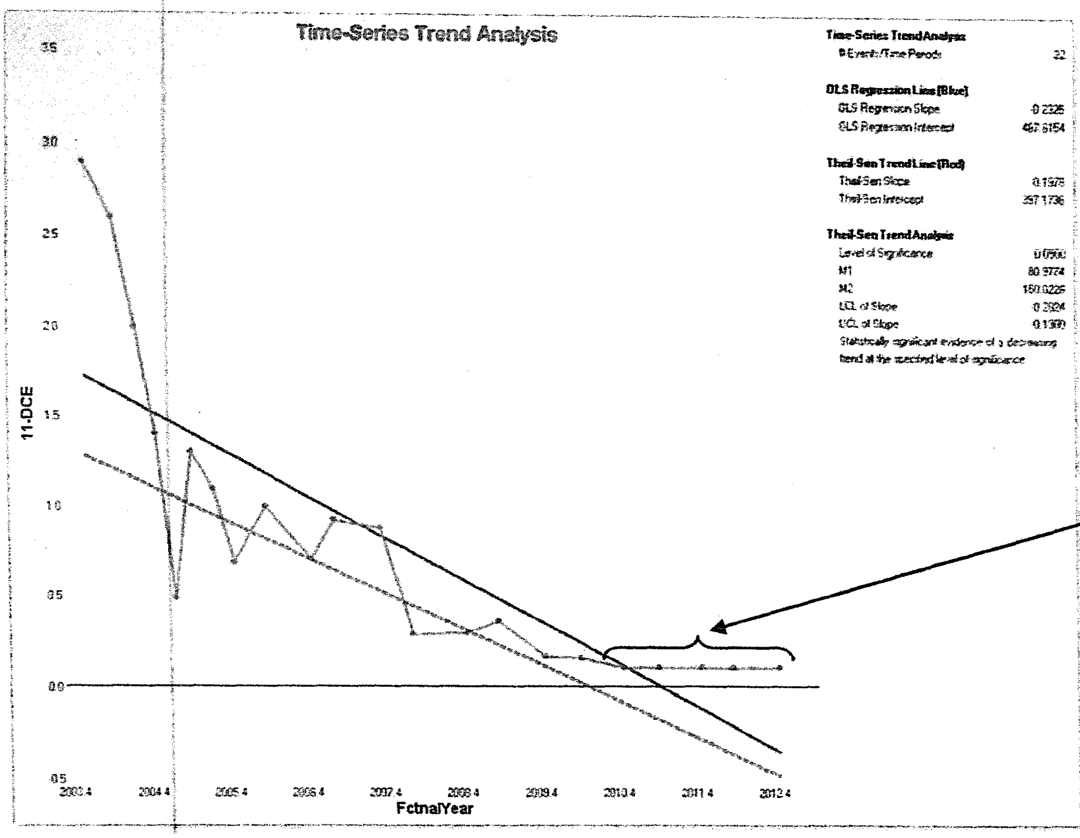
Constituent	Units	Well	N	% Detected	Mean	90% LCL	95% UCL	Standard	Limit Type	Trend	Notes
1,1,1-trichloroethane	ug/L	B-326-WD	22	0.864	0.160	0.000	0.046	200.000	normal	dec	
1,1,2,2-tetrachloroethane	ug/L	B-326-WD	22	0.000	0.200	0.200	0.200	1.000	nonpar		
1,1,2-trichloroethane	ug/L	B-326-WD	22	0.000	0.270	0.270	0.270	5.000	nonpar		
1,1-dichloroethane	ug/L	B-326-WD	22	0.864	0.220	0.000	0.154	990.000	normal	dec	
1,1-dichloroethene	ug/L	B-326-WD	22	0.773	0.230	0.000	0.137	7.000	normal	dec	
1,2-dichloroethane	ug/L	B-326-WD	22	0.000	0.130	0.130	0.130	5.000	nonpar		
1,2-dichloropropane	ug/L	B-326-WD	22	0.182	0.155	0.099	0.210	5.000	nonpar		
1,4-dioxane	ug/L	B-326-WD	43	1.000	0.000	0.000	0.000	5.000	normal	dec	
Acetone	ug/L	B-326-WD	22	0.136	2.100	2.300	1.900	1600.000	nonpar		
Arsenic	ug/L	B-326-WD	22	0.091	4.864	5.327	4.400	52.180	nonpar		

Figure 3. Plot of B-326-WD data for 1,1-dichloroethane (11DCA)



The last 3 data points are NDs plotted at half the MDL.

Figure 4. Plot of B-326-WD data for 1,1-dichloroethene (11DCE)



The last 5 data points are NDs plotted at half the MDL.

Using MDLs as a "mean" is not only inappropriate, but it also creates the mathematically impossible situation where the "95%UCLs" in Table 1 are lower than the value used as the "mean."

EPA is unable to determine how the values reported as "95%UCLs" for 1,1-DCA (0.154) and 1,1-DCE (0.137) in the Table 1 excerpt above were obtained. Many calculation options were explored. The number of permutations is increased because of the ND data points in these two data sets. There are three substitution techniques for handling the NDs, and one preferred statistical technique. Therefore, mathematical calculation of a "mean" has four options. Applying the GWMP regression procedure only has the three substitution options. The GWMP procedure was used for 1,4-dioxane for this well also. Other results of alternate calculations for the 1,4-dioxane mean and 95% UCL are included at the bottom of the table below.

The values obtained for these permutations and for the full data set vs. the data set covering the last 5 years for well B-326-WD are listed in the table titled "Full and 5-year Data Set Statistics for B-326-WD, below.

- The three red text rows in the table display the "mean" and "95%UCL" as given in the Status Report's Table 1 (for 1,1-DCA, 1,1-DCE and 1,4-dioxane).
- The darker blue text displays the values obtained by ordinary calculation of the mean and UCL under the 4 different ND-handling techniques:
    - KM: the Kaplan-Meier technique is a statistical technique for handling NDs. This technique is preferred over direct substitution of some multiple of the MDL. Simple substitution techniques have been shown to produce unreliable summary statistics and bias the outcome of statistical tests, such as one- or two-sample t-tests (Helsel 2005a, 2005b, 2006, 2012;

USEPA 2013). The following 3 substitution techniques should be avoided, but are provided in the table below for comparison purposes:

- ND = DL: Substitution of the full MDL value for the ND;
- ND = ½DL: Substitution of ½ of the MDL value (this technique was recommended in EPA guidance in the past, and so has become common; but evaluation of its performance shows that the KM technique should be used instead); and
- ND = 0: Substitution of zero for the ND.

- The lighter blue/aqua text displays the values obtained if linear regression is used to determine the value at the last monitoring event (the GWMP procedure). The three most common substitution techniques for handling NDs were used in iterations of the GWMP procedure to see if one of them gave the values provided in the Status Report's Table 1.
- The purple text displays the mean and 95%UCL that would be obtained if only the past 5 years of data are used, which coincides with stabilization concentration declines had somewhat stabilized. This is a more representative portrayal of current concentrations. The KM technique (bolded) is preferred. The values obtained by direct substitutions are presented for comparison purposes only. The **bold purple text** indicates the data values that would be the most appropriate to use as summary statistics in Table 1.

Full and 5-Year Data Set Statistics for B-326-WD

Data Set & ND-Handling Technique	Data Set "n"	Number of NDs	Mean	95% UCL
Analyte: 1,1-Dichloroethane (1,1-DCA)				
Given in Report's Table 1; "mean" = MDL; unk UCL calc method	**22**	**3**	**0.22**	**0.154**
All data: KM technique to handle NDs; ordinary math	22	3	1.23	1.66
ND=DL; ordinary math	22	3	1.23	1.65
ND=½DL; ordinary math	22	3	1.21	1.64
ND=0; ordinary math	22	3	1.21	1.64
All data: ND=DL; linear regr. value @ last sampling date	22	3	<0	0.249
ND=½DL; linear regr. value @ last sampling date	22	3	<0	0.181
ND=0; linear regr. value @ last sampling date	22	3	<0	0.115
Last 5 years of data (Oct07-May12): KM; math	**10**	**3**	**0.32**	**0.39**
ND=DL; math	10	3	0.32	0.39
ND=1/2DL; math	10	3	0.29	0.38
ND=0; math	10	3	0.25	0.37
Analyte: 1,1-Dichloroethene (1,1-DCE)				
Given in Report's Table 1; "mean" = MDL; unk UCL calc method	**22**	**5**	**0.23**	**0.137**
All data: KM technique to handle NDs; ordinary math	22	5	0.82	1.12
ND=DL; ordinary math	22	5	0.84	1.13
ND=½DL; ordinary math	22	5	0.81	1.11
ND=0; ordinary math	22	5	0.81	1.11
All data: ND=DL; linear regr. value @ last sampling date	22	5	<0	0.207
ND=½DL; linear regr. value @ last sampling date	22	5	<0	0.101
ND=0; linear regr. value @ last sampling date	22	5	<0	<0
Last 5 years of data (Oct07-May12): KM; math	**10**	**5**	**0.21**	**0.26**
ND=DL; math	10	5	0.24	0.28
ND=1/2DL; math	10	5	0.19	0.24
ND=0; math	10	5	0.13	0.21
Analyte: 1,4-Dioxane				
Given in Report's Table 1; based on improper GWMP procedure	**43**	**None**	**0.000**	**0.000**
All data from Jul2003 to May2012; math (gamma UCL)	43	None	196	277
Last 5 years of data (Oct07 to Nov12); math	**21**	**None**	**28.6**	**36.1**

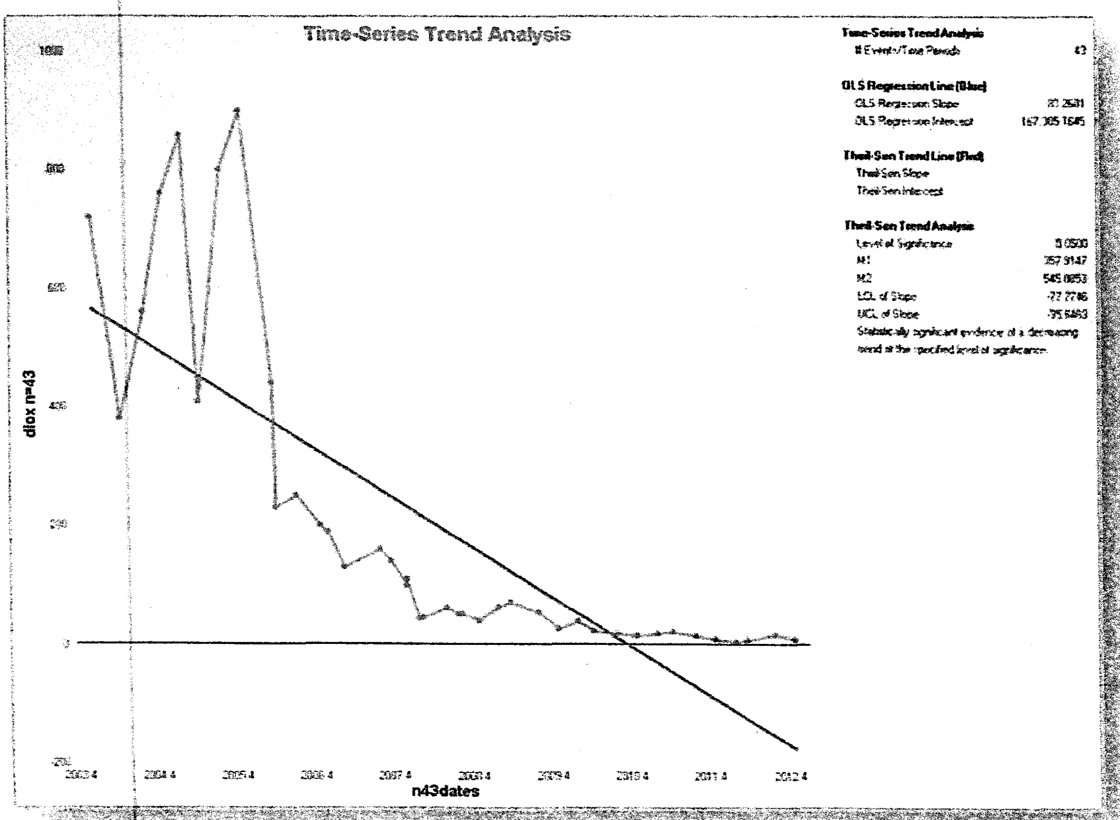
48

Below is a concise summary of the table above, showing what was reported in the Status Report versus what EPA believes to be fair and accurate representation of the summary data (last 5 years) for B-326-WD.

Comparison of Status Report summary statistics vs. preferred statistical analysis for 3 B-326-WD analytes

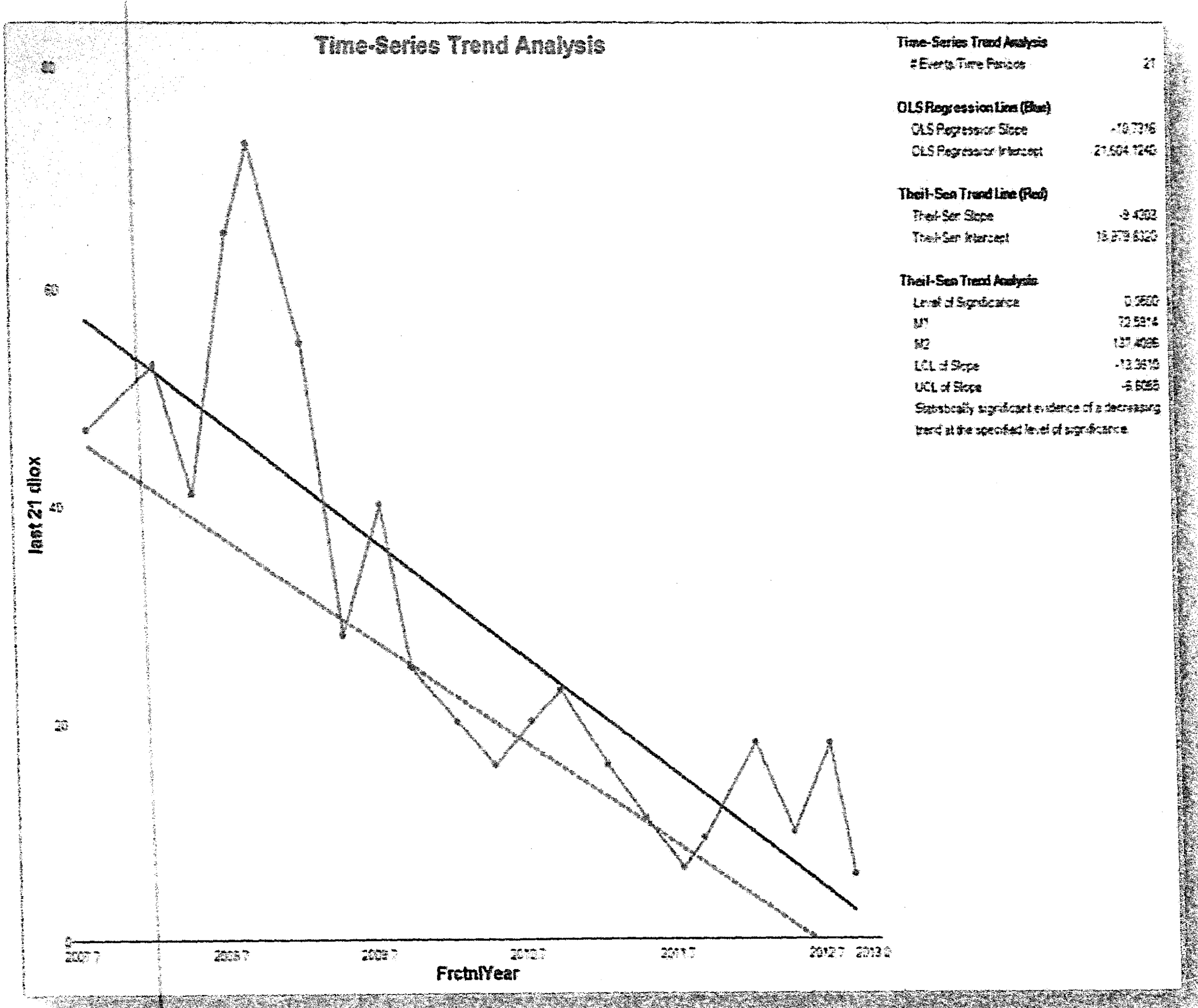
Data Set & ND-Handling Technique	Data Set "n"	Number of NDs	Mean	90%LCL	95%UCL
B-326-WD 1,1-Dichloroethane (11DCA)					
Given in Status Report's Table 1 (Jul03-May12)	22	3	0.22	0.000	0.154
Last 5 years of data (Oct07-May12)	10	3	0.32	0.26	0.39
B-326-WD 1,1-Dichloroethene (11DCE)					
Given in Status Report's Table 1 (Jul03-May12)	22	5	0.23	0.000	0.137
Last 5 years of data (Oct07-May12)	10	5	0.21	0.18	0.26
B-326-WD 1,4-Dioxane					
Given in Status Report's Table 1 (Jul03 to May12)	43	None	0.000	0.000	0.000
Last 5 years of data (Oct07-Nov12)	21	None	28.6	22.8	36.1
Note: B-326-WD 1,4-dioxane is <u>clearly out of compliance</u>, but it does not appear in Table 4.6 & is not ID'd in Table 1					
see 1,4-dioxane plots, for n = 43 and for n = 21 below (note change of y-axis scale & time period in n = 21 data set)					

Figure 5. B-326-WD: Plot of the 43 1,4-dioxane data points referenced in the table above



40

Figure 6. B-326-WD: Plot of the 21 1,4-dioxane data points for the last 5 years



MW 38

MW38-830N-230E

EPA also evaluated four analytes from Well MW38-830N-230E. The data for each analyte was retrieved from the Site database file, and analyzed according to standard procedures for the full data set (May 2005 to November 2012) and for only the last five years of monitoring (October 2007 to November 2012). The summary statistics were compared to values presented in the Status Report's Tables 1 and 4.6. A table to summarize the findings appears below.

Data Summaries for Selected Analytes from MW38-830N-230E

Data Set & ND-Handling Technique	Data Set "n"	# of NDs	Mean	90%LCL	95%UCL
MW380830N-230E chloroform (improper GWMP procedure used)					
Given in Status Report's Table 4.6 (May05-Nov12)	20	none	5.0	2.0	8.9
Properly reported for full data set	20	none	33.2	28.3	39.6
Last 5 years of data (Oct07-Nov12)	**11**	**none**	**21.6**	**17.1**	**27.5**
MW380830N-230E chloroform: the lowest concentration in the n = 20 data set is 9.4 (max is 58); standard is 3.5					
It is impossible for a mean to be 5.0 when the lowest concentration is 9.4					
MW380830N-230E tetrachloroethene (PCE) (improper GWMP procedure used)					
Given in Status Report's Table 1 (May05-May12)	19	none	0.431	0.000	1.145
Properly reported for full data set	19	none	4.5	2.8	5.4
Last 5 years of data (Oct07-Nov12)	**11**	**none**	**2.6**	**1.9**	**3.4**
MW380830N-230E PCE: the lowest concentration in the n = 19 data set is 1 (max is 8.1); standard is 5					
It is impossible for a mean to be 0.431 when the lowest concentration is 1.0					
MW380830N-230E trichloroethene (TCE) (improper GWMP procedure used)					
Given in Status Report's Table 1 (May05-May12)	19	none	3.289	0.958	6.33
Properly reported for full data set	19	none	25.3	21.4	30.4
Last 5 years of data (Oct07-Nov12)	**11**	**none**	**15.3**	**11.6**	**20.1**
MW380830N-230E TCE: the lowest concentration in the n = 19 data set is 6 (max is 44); standard is 5					
****Note: MW380830N-230E TCE is <u>clearly out of compliance</u> (all monitoring data are greater than the standard),**** yet TCE does not appear in Table 4.6 and is not identified as out of compliance in Table 1					
MW380830N-230E 1,4-Dioxane (improper GWMP procedure used)					
Given in Status Report's Table 4.6 (May05-Nov12)	20	none	0.000	0.000	10.3
Properly reported for full data set	20	none	85.4	68.8	107
Last 5 years of data (Oct07-Nov12)	**11**	**none**	**43.3**	**32.5**	**57.5**
****Note: MW380830N-230E 1,4-Dioxane is <u>clearly out of compliance</u> (the lowest concentration is 17),**** yet Table 4.6 says the compliance decision is "Insufficient Data"					